

***Eimeria rheemi* sp. n. (Apicomplexa: Eimeriidae) from the Arabian Sand Gazelle, *Gazella subgutturosa marica* (Artiodactyla: Bovidae) in Saudi Arabia**

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ABSTRACT: Oocysts of *Eimeria rheemi* sp. n. were detected in the feces of 35 out of 73 (48%) rheem or Arabian sand gazelles, *Gazella subgutturosa marica* Thomas, 1897, examined at King Khalid Wildlife Research Center, Thumamah, Riyadh Province, Saudi Arabia. Sporulated oocysts of *E. rheemi* sp. n. are spherical or ovoid, 25×21 ($20\text{--}34 \times 18\text{--}30$) μm , with smooth, double-layered wall and micropyle, but no micropylar cap. The outer oocyst layer is yellow, almost twice as thick as the bluish-green inner one. Sporocysts oval, 10×8 ($6\text{--}15 \times 5\text{--}10$) μm , each with a Stieda body and residuum. Sporozoites elongate 9 ($7\text{--}11$) μm , each with a single refractile globule 3 ($2\text{--}4$) μm in diameter at the wider end. Sporulation time 24 hr at $25 \pm 2^\circ\text{C}$ in aqueous $\text{K}_2\text{Cr}_2\text{O}_7$. *Eimeria rheemi* sp. n. is pathogenic to young rheem ($2\text{--}4$ mo old) causing mild to severe mucoid diarrhea, commensurate with the fecal oocyst count and has responded well to sulphonamide treatment.

KEY WORDS: antelope, coccidia, *Eimeria rheemi*, gazelle, mucoid diarrhea, oocyst, sporocyst, sporozoite, Stieda body.

There are 5 species of gazelles indigenous to the Arabian peninsula, 3 of which, *Gazella gazella* Pallas, 1766, *Gazella dorcas* Linnaeus, 1758, and *Gazella subgutturosa* Gueldenstaedt, 1780, are widespread (Groves and Lay, 1985; Groves, 1989). However, the subspecies *Gazella subgutturosa marica* Thomas, 1897, the Arabian sand gazelle or rheem of the Nafud desert of Saudi Arabia, is endangered (Honacki et al., 1982). Sizeable herds of the rheem and the other 2 endangered antelopes of Saudi Arabia, the idmi (*Gazella gazella*) and the Arabian oryx, *Oryx leucoryx* (Honacki et al., 1982), are kept together with the ifri (*Gazella dorcas*) at King Khalid Wildlife Research Center (KKWRC) of the National Commission for Wildlife Conservation and Development (NCWCD) in Thumamah, 80 km north of Riyadh, the capital of Saudi Arabia, for research, breeding, and later reintroduction into their now protected natural habitats in the country.

Recently, 2 new species of *Eimeria* have been described from these animals: *Eimeria saudienis* from the Arabian oryx (Kasim and Al-Shawa, 1988) and *Eimeria idmii* from the idmi or Arabian mountain gazelle (Mohammed and Hussein, 1992). No *Eimeria* species was detected in the ifri (*G. dorcas*), but the rheem herd was infected with an unknown eimerian which is described in the present study.

Materials and Methods

The herds of gazelles and the Arabian oryx at KKWRC are born and bred in Thumamah and they are descendants of animals collected by the late King Khalid Ibn Abdul Aziz. A total of 73 ($2\text{--}36$ mo old) rheems, 55 adults ($24\text{--}36$ mo old) and 18 young ($2\text{--}4$ mo old), has been examined for parasitological assessment. The adults were sedated by darts and the young were sick gazelles that have been segregated in the treatment stalls of the veterinary clinic of the Center for diagnosis and treatment. Fresh fecal samples were collected directly from the rectum of each of the animals into wide-mouth, screw-cap, plastic containers. In the laboratory, the fecal samples were subjected to various parasitological examinations, including direct smear, sedimentation, and flotation over saturated sodium chloride solution, and the parasite prevalence and intensity for each animal was assessed by the modified McMaster technique (Anonymous, 1977). Fecal samples from the 18 young, sick gazelles were also sent to the microbiology laboratory of the Center for microbiological assessment.

Fecal samples with eimerian oocysts were sporulated at room temperature ($25 \pm 2^\circ\text{C}$) in thin layers of aqueous potassium dichromate as outlined by Mohammed and Hussein (1992). The 18 sick gazelles were drenched with an aqueous suspension of sulphadimidine at a dose of 30 mg per kg body weight for 10 consecutive days, and fecal samples were obtained from them for the assessment of the daily output of *Eimeria* oocysts. They were also clinically assessed throughout the treatment period, following which they were discharged to join the rest of the herd. Thereafter, sulphonamide treatments at low concentrations were periodically given in drinking water for all herds for the control of coccidiosis as outlined by Soulsby (1982).

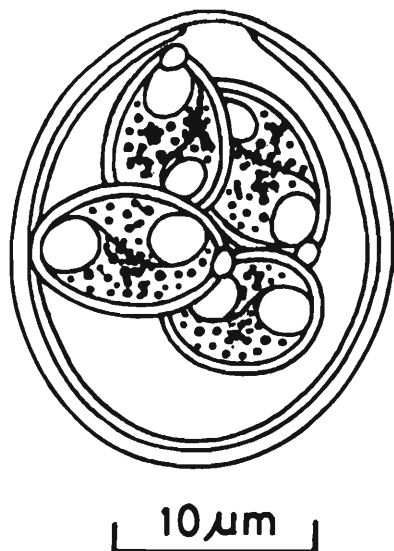


Figure 1. Camera lucida drawing of a sporulated oocyst of *Eimeria rheemi* sp. n.

Measurements were made by a calibrated ocular micrometer, photographs were taken by a Nikon camera (Nikon Company, Japan) attached to a Zeiss compound microscope (Karl Zeiss, Jena, Germany), and drawings were made using an attached Zeiss camera lucida. All measurements are in micrometers (μm); means followed in parentheses by the range.

Results

All of the 18 young, sick gazelles had mild to severe mucoid diarrhea and all were shedding

large numbers (100,000–300,000 oocysts g^{-1} feces) of oocysts of an *Eimeria* sp. The severity of the diarrhea coincided with the oocyst count, but dramatically subsided with the initiation of the sulphonamide treatment. Daily counts progressively dropped from 100,000–300,000 oocysts g^{-1} feces on day 1 of treatment to 50–300 oocysts g^{-1} feces on day 10.

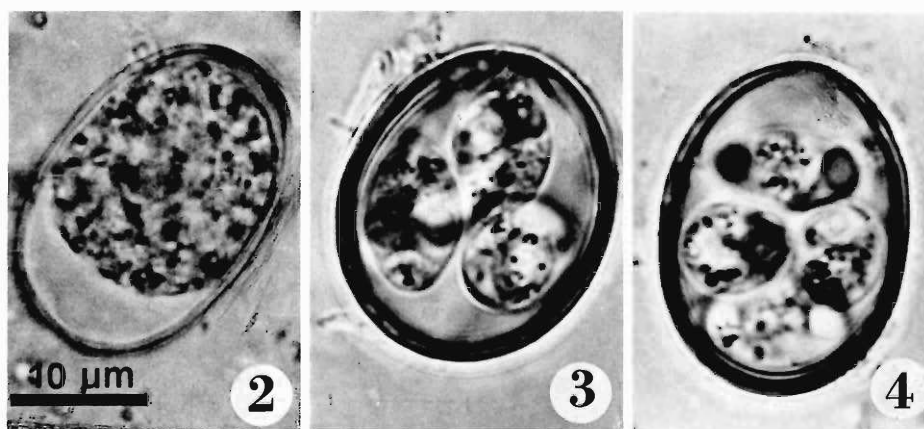
On the other hand, 15 of the 55 adult rheems were shedding oocysts of the same eimerian, but at considerably lower rates (100–10,000 oocysts g^{-1} feces) and all were healthy. Oocysts from young or adult rheems sporulated within 24 hr at room temperature ($25 \pm 2^\circ\text{C}$). Careful examination of the sporulated oocysts showed that they belong to an eimerian that is morphologically different from any described from gazelles or from any other antelope species of the family Bovidae. Hence, they represent a new *Eimeria* species that is described below.

Eimeria rheemi sp. n.

(Figs. 1–4)

DESCRIPTION: Oocysts spherical or ovoid. Oocyst wall 1.6 (1–2) thick, smooth, double-layered, outer layer yellow, almost twice as thick as bluish-green inner one. Micropyle present, 5.6 (5–6) wide, micropylar cap absent.

Sporulated oocysts ($N = 500$) 25×21 (20–34 \times 18–30), length/width ratio 1.2 (1–1.6). Oocyst residuum, oocyst polar granule both absent. Sporocysts ($N = 750$) oval, 10×8 (6–15 \times 5–10), length/width ratio 1.5 (1–2.4), with sporocyst re-



Figures 2–4. Photomicrographs of wet mounts of *Eimeria rheemi* sp. n. oocysts in aqueous $\text{K}_2\text{Cr}_2\text{O}_7$. 2. An unsporulated oocyst. 3. A spherical sporulated oocyst; the micropyle is clearly depicted in this figure. 4. An ovoid sporulated oocyst. The scale bar is for all figures.

siduum as dispersed fine granules. Stieda body present, substiedal body absent. Sporozoites ($N = 750$) ovoid to elongate, 9 (7–11) long, each with single spherical globule at the wider end, 3 (2–4) in diameter.

TYPE HOST: The rheem or the Arabian sand gazelle, *Gazella subgutturosa marica* Thomas.

TYPE LOCALITY: Thumamah, Riyadh Province, Saudi Arabia.

PREVALENCE: Found in 35 of 73 (48%) rheems.

SITE OF INFECTION: Unknown, oocysts recovered from feces.

SPORULATION: Exogenous. Oocysts sporulated in 24 hr at $25 \pm 2^\circ\text{C}$ in $\text{K}_2\text{Cr}_2\text{O}_7$.

TYPES: Phototypes and preserved materials in authors' collection at the Zoology Department, College of Science, King Saud University, and at KKWRC, Riyadh, Saudi Arabia.

PHOTOTYPES: Deposited in the National Parasite Collection, U.S. National Museum, USNM No. 82103.

ETYMOLOGY: The specific name is derived from the common Arabic name of the type host.

Discussion

Six species of *Eimeria* have been described from the genus *Gazella* Blainville, 1816, of the family Bovidae and have recently been reviewed by Mohammed and Hussein (1992). These are *Eimeria abenovi* Svanbaev, 1979, *Eimeria elegans* Yakimoff, Gousseff, and Rastegaieff, 1932, and *Eimeria gazella* Musaev emend. Svanbaev, 1979, from the goittered gazelle, *G. subgutturosa*; *Eimeria chinkari* Pande, Bhatia, Chauhan, and Garg, 1970, and *Eimeria idmii* Mohammed and Hussein, 1992, from *G. gazella*; and *Eimeria dorcadis* Montovani, 1966, from *G. dorcas*. However, oocysts of *E. rheemi* sp. n. differ considerably from all of these species. Similar to other gazelle eimerians (Levine and Ivens, 1986; Mohammed and Hussein, 1992), oocysts of *E. rheemi* differ from those of *E. idmii* in being smaller and in lacking a micropylar cap. The outer layer of the oocyst wall of *Eimeria rheemi* is yellow and almost twice as thick as the bluish-green inner one. Both layers of the oocyst wall of *E. idmii* are similar in thickness, but the outer layer is green and the inner is yellow. Moreover, *E. rheemi* is pathogenic to young gazelles and sporulates within 24 hr at $25 \pm 2^\circ\text{C}$ in $\text{K}_2\text{Cr}_2\text{O}_7$, compared to the nonpathogenic *E. idmii* that sporulates in 7–8 days under the same condi-

tions. Also, each sporozoite of *E. rheemi* has a single refractile globule at its wider end, whereas each of those of *E. idmii* has 2, 1 at either end (Mohammed and Hussein, 1992). Refractile globules are also present at either end of each sporozoite of *E. abenovi* and *E. chinkari* (Pande et al., 1970; Svanbaev, 1979; Levine and Ivens, 1986), but are absent from those of *E. elegans* and *E. gazella* (Yakimoff et al., 1932; Montovani, 1966; Levine and Ivens, 1970, 1986; Pellérdy, 1974; Svanbaev, 1979).

Eimeria rheemi is somewhat larger than either *E. chinkari* or *E. gazella*, both of which also lack a micropyle; *E. gazella* lacks a Stieda body (Pande et al., 1970; Svanbaev, 1979; Levine and Ivens, 1986). A micropyle is also found in both *E. abenovi* and *E. elegans*, but it is much larger than that of *E. rheemi*, and both lack Stieda bodies (Yakimoff et al., 1932; Svanbaev, 1979; Levine and Ivens, 1986). On the other hand, *E. dorcadis* is somewhat larger than *E. rheemi*, but it lacks a micropyle as well as Stieda bodies (Montovani, 1966; Levine and Ivens, 1986). With the exception of *E. abenovi*, all gazelle eimerians, including *E. rheemi*, have sporocyst residua, but all lack oocyst residua and polar granules (Svanbaev, 1979; Levine and Ivens, 1986; Mohammed and Hussein, 1992).

Moreover, *E. rheemi* can easily be differentiated from all of the 21 *Eimeria* species described from other antelopes and recently reviewed by Mohammed and Hussein (1992). It is smaller than *E. saudiensis*, *E. yakimovae*, *E. congolensis*, *E. kobi*, *E. macieli*, *E. talbotti*, *E. mirgai*, *E. impalae*, *E. neitzi*, *E. walleri*, *E. ismailovae*, *E. manafovae*, *E. saiga*, *E. tatarica*, and *E. tekenovae*, about the same size as *E. canna* and *E. chausinghi*, but is larger than *E. truffittae*, *E. gorgonis*, *E. connochaetei*, and *E. sajanica*. It also differs from *E. saudiensis*, *E. mirgai*, *E. tekenovi*, and some oocysts of *E. tatarica* in lacking a micropylar cap (refer to Table 1, Mohammed and Hussein, 1992). *Eimeria saudiensis*, *E. mirgai*, *E. canna*, *E. gorgonis*, *E. neitzi*, *E. manafovae*, and *E. saiga* are the only antelope eimerians that have oocyst polar granules; the rest, similar to *E. rheemi*, are devoid of these (Levine and Ivens, 1970, 1986; Pellérdy, 1974). Moreover, a micropyle is present in *E. rheemi* as well as in most antelope eimerians with the exception of *E. neitzi*, *E. connochaetei*, *E. gorgonis*, *E. talboti*, *E. chausinghi*, *E. truffittae*, *E. ismailovae*, *E. saiga*, and *E. sajanica* (Levine and Ivens, 1986; Mo-

ammed and Hussein, 1992). Stieda bodies are present in most antelope eimerians as well as in *E. rheemi*, but are absent from *E. triffittae*, *E. macieli*, *E. talboti*, *E. ismailovae*, *E. manafovae*, *E. saiga*, *E. sajanica*, *E. tatarica*, and *E. tekenovae* (Levine and Ivens, 1986; Mohammed and Hussein, 1992). Similar to *E. rheemi*, most antelope eimerians with the exception of *E. triffittae*, *E. congolensis*, *E. macieli*, *E. talboti*, and *E. impalae* have a sporocyst residuum (Levine and Ivens, 1986; Mohammed and Hussein, 1992).

Eimeria neitzi and *E. triffittae* are the only antelope eimerians whose oocysts are single-layered (Yakimoff, 1934; Levine and Ivens, 1970, 1986; McCully et al., 1970; Pellérdy, 1974). *Eimeria canna* and *E. walleri* are the only ones with triple-layered oocysts (Triffitt, 1924; Prasad, 1960; Levine and Ivens, 1970, 1986; Pellérdy, 1974), whereas all other antelope eimerians, as well as *E. rheemi*, have double-layered oocysts (Levine and Ivens, 1970, 1986; Pellérdy, 1974; Mohammed and Hussein, 1992). Similar to *E. idmii* (Mohammed and Hussein, 1992), both layers of the oocyst wall of *E. rheemi* are smooth, colored, and firmly attached to each other, whereas oocysts of both *E. congolensis* and *E. kobi* have a rough, granular, brown-colored outer layer that easily separates from its inner layer (Ricci-Bitti et al., 1973; Levine and Ivens, 1986). The oocyst walls of *E. sajanica* and *E. saiga* are colorless (Svanbaev, 1958; Levine and Ivens, 1970, 1986; Pellérdy, 1974) and that of *E. macieli* is radially striated (Yakimov and Matchuski, 1938; Levine and Ivens, 1970, 1986; Pellérdy, 1974). Hence, *E. rheemi* sp. n. appears to be a distinct and hitherto undescribed species.

The present results also demonstrate that *E. rheemi* sp. n. is pathogenic to young gazelles causing mucoid diarrhea that varies in severity with the fecal oocyst counts. Infections responded well to sulphonamide treatment. Animals at KKWRC are kept under excellent conditions with plenty of room to roam and are never allowed to crowd up in any single spot. Camels kept under similar conditions in Saudi Arabia never suffer from coccidiosis, but when they congregate in limited areas, either around water holes during the short rainy season, or in oases or in farms, young camels often develop clinical coccidiosis (Kawasmeh and El Bihari, 1983; Hussein et al., 1987). A similar situation was also reported in the impala in South Africa, which developed severe coccidiosis due to *E. impalae* infection only

when they were brought together in small paddocks (Pinnaar et al., 1964; Bigalke, 1966). This indicates that *E. rheemi* might be more pathogenic than either *E. impalae* in South Africa (Pinnaar et al., 1964; Bigalke, 1966) or any of the camel eimerians reported in Saudi Arabia (Kawasmeh and El Bihari, 1983; Kasim et al., 1985; Hussein et al., 1987). In young rheems it causes mild to severe coccidiosis even under the excellent prevailing conditions at KKWRC. However, more studies are needed to determine the extent of *E. rheemi* pathogenicity.

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